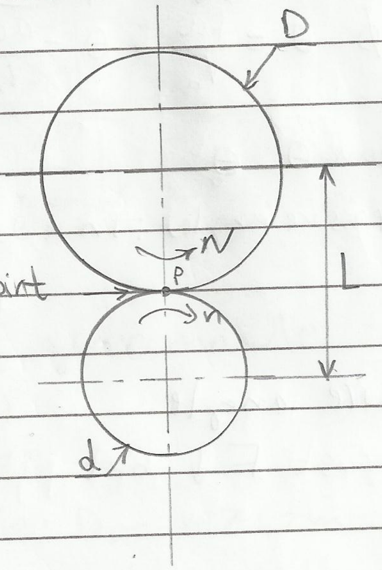
7- Gear measurement

* Friction wheels

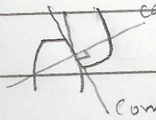
- For low Power & high friction transmission



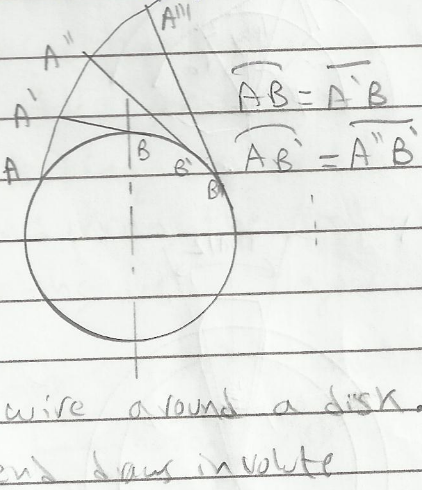
$$\frac{n}{N} = \frac{D}{d}$$

* Gears:

- Positive transmission in which high power is transmitted
- Tooth curves → Involute → Easier to manufacture and wear
  → Cycloidal → Difficult to manufacture & strong (casting)
  → Straight for rack
- common normal must intersect centre line for fixed r.n during contact of tooth interval



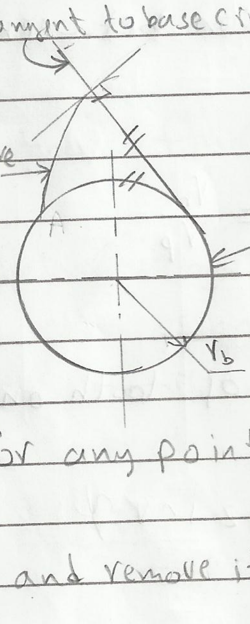
* The involute curve:



$\overline{AB} = \overline{A'B}$

$\overline{AB'} = \overline{A''B'}$

-



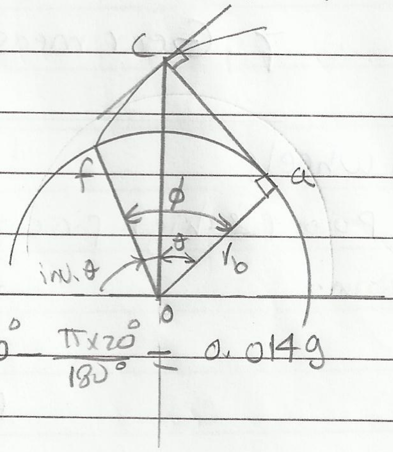
For any point on involute

- Circle a wire around a disk. Pull the wire and remove it as well so wire end draws involute
- Move a pencil around a disk to draw the involute curve
- Tangent on base circle ⊥ involute curve
  Normal to involute curve is tangent to base circle

*** Involute function:**

- From definition: $\overline{ac} = \overset{\frown}{af}$

$$inv.\theta = \phi - \theta = \frac{\overset{\frown}{fa}}{r_b} - \theta = \frac{\overline{ac}}{r_b} - \theta$$

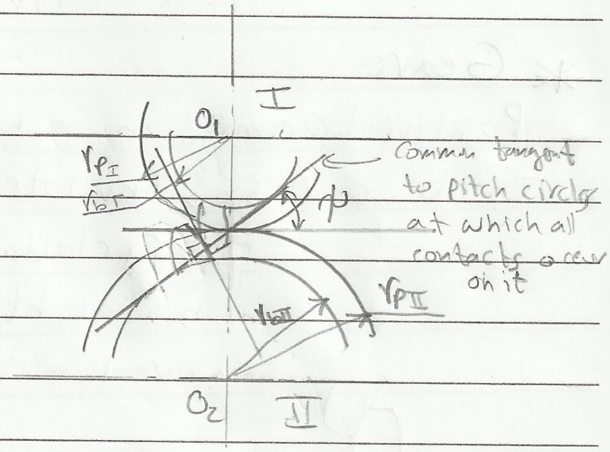


$$inv.\theta = \tan\theta - \theta$$

For $\psi = 20^\circ$ (pressure angle): $inv.\theta = \tan 20^\circ - \frac{\pi \times 20^\circ}{180^\circ} = 0.0149$

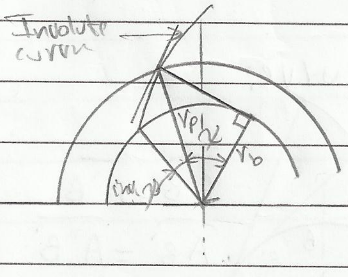
*** The pressure angle**

- $\psi \downarrow \Rightarrow$ Thrust $F \downarrow$ but it's week



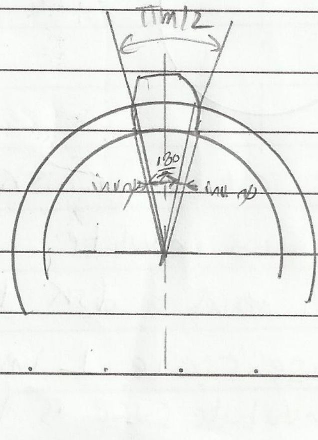
*** Relation between pressure angle & circles:**

$$\cos\psi = \frac{r_b}{r_p}$$



*** Angle of tooth on base circle:**

$$\theta = \frac{180}{z} + 2\,inv.\psi$$

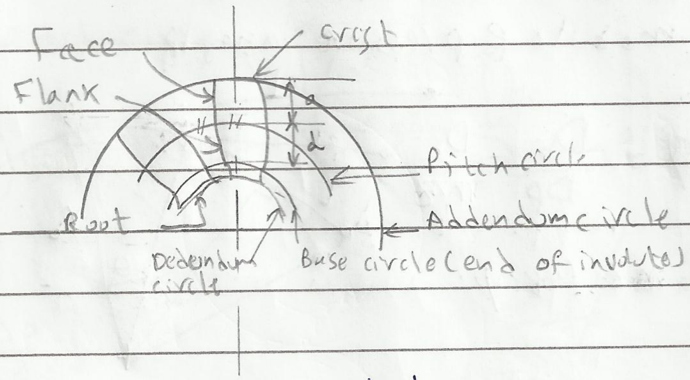


* Parameters of gear

$a = m$

$d = 1.25m$ (for clearance)

Tooth depth $= a + d = 2.25m$



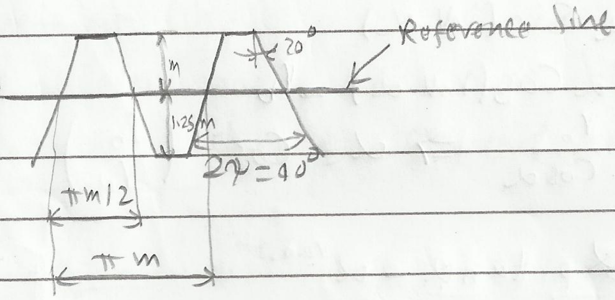
* Experimental prediction of gear module

1- Measure addendum circle (D_a)
2- Count the no. of teeth (Z)
3- Determine the gear module: $D_a = mZ + 2m = m(Z+2)$
4- Select the nearest standard module

* Involute rack:

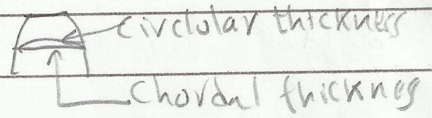
Tooth thickness (arc) at pitch circle

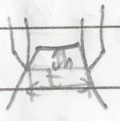
$$= \frac{\pi D_P}{2Z} = \frac{\pi m Z}{2Z} = \frac{\pi m}{2}$$

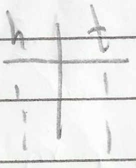


* Experiment: check the form of the tooth flank (involute)

1- Determine the module of gear
2- Draw the profile of flank of tested gear by
   A- Projecting the profile of gear tooth flank using projector
   B- Measuring the tooth thickness (chordal) at different tooth depths using gear tooth vernier, T.M.M, etc.







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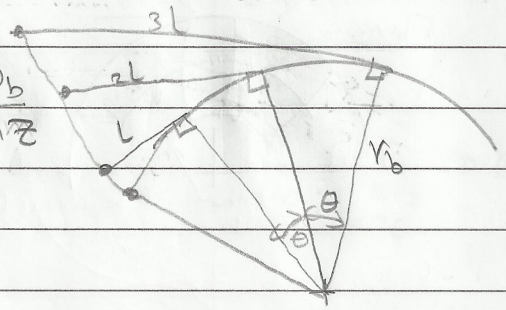
3- Draw the theoretical involute curve for the given module of pressure angle



$\cos\psi = \frac{D_b}{D_p} = \frac{D_b}{mZ}$

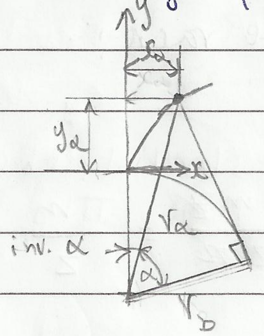
$D_b = mZ\cos\psi$

$L = r_b \times \frac{\overset{\circ}{\theta}\pi}{180^\circ}$

$\theta \rightarrow 5^\circ$

4- Compare the actual profile with the theoretical one

* Drawing of involute curve without drawing of base circle;



$x_\alpha = r_\alpha \sin(inv.\alpha)$

$y_\alpha = r_\alpha \cos(inv.\alpha) - r_b$

$r_\alpha = \frac{r_b}{\cos\alpha} \Rightarrow \alpha = \cos^{-1}\left(\frac{r_b}{r_\alpha}\right)$

$inv.\alpha = \tan\alpha - \alpha^{rad.}$

r_i	α ($\cos^{-1}\frac{r_b}{r_\alpha}$)	$inv\alpha$ ($\tan\alpha - \alpha^{rad}$)	x_α	y_α
r_d				
⋮				
r_p				
⋮				
r_a				

$r_d = \frac{mZ}{2} - 1.25m = \frac{m}{2}(Z - 2.5)$

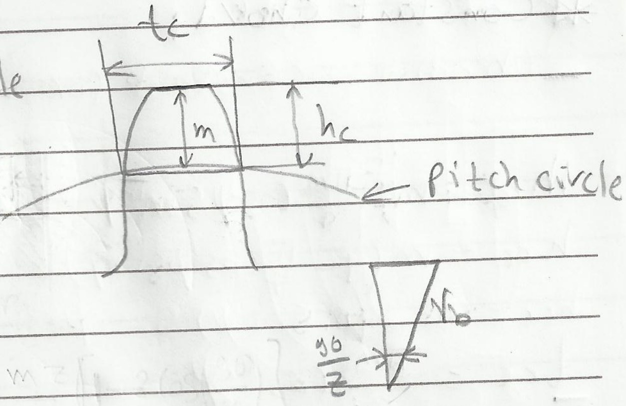
$r_p = \frac{mZ}{2}$

$r_a = \frac{mZ}{2} + m = \frac{m}{2}(Z + 2)$

* Chordal thickness:

(t_c) Chordal thickness of pitch circle

(h_c) Chordal height



$$t_c = 2 r_p \sin\left(\frac{90}{z}\right) = 2\left(\frac{mz}{2}\right)\sin\left(\frac{90}{z}\right)$$

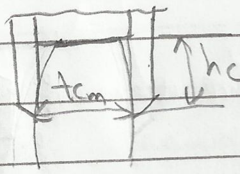
$$t_c = mz \sin\left(\frac{90}{z}\right)$$

$$h_c = m + \left[r_p - r_p \cos\left(\frac{90}{z}\right)\right]$$

$$h_c = m + \frac{mz}{2}\left[1 - \cos\left(\frac{90}{z}\right)\right]$$

o Experimental procedure:

1- Measure outer diameter
2- Count no. of teeth
3- Determine the module
4- Approximate to the nearest standard module
5- Calculate the chordal height (h_c)
6- Set the vertical vernier of gear tooth vernier on (h_c) value
7- Set it on the tooth tip as shown in figure & measure its thickness (t_{c_m})



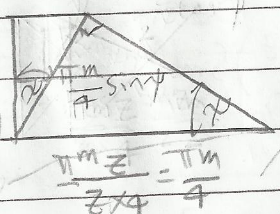
8- Calculate the chordal thickness theoretically ; $t_c = mz \sin\left(\frac{90}{z}\right)$
9- Determine the error in chordal thickness $\Delta = t_{cm} - t_c$

* Constant chord;

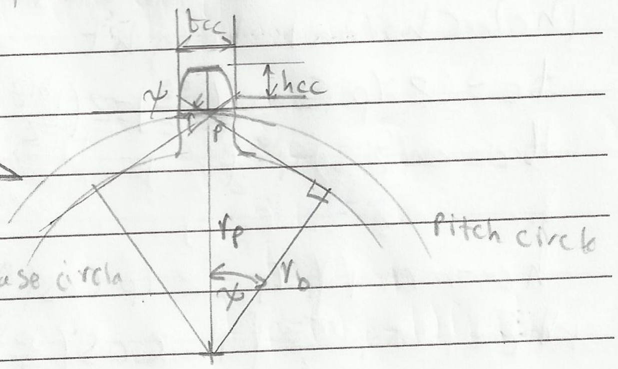
_ (h_{cc}) is constant for all gears of same module

$$h_{cc} = m - \frac{\pi m}{4}\cos\psi\sin\psi$$

$$h_{cc} = m\left(1 - \frac{\pi}{4}\cos\psi\sin\psi\right)$$



$$t_{cc} = \frac{\pi m}{2}\cos^2\psi$$



Experimental procedure:

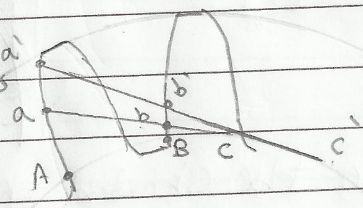
1_ D_o
2_ Z
3_ m
4_ m_{st}
5_ h_{cc}, calculated
6_ t_{cc}, measured by gear tooth vernier
7_ t_{cc}, calculated
8_ $\Delta = t_{cc_m} - t_{cc}$

* Base pitch: Normal distance between 2 invs

$\overline{AB} = \overline{ab} = \overline{a'b'}$

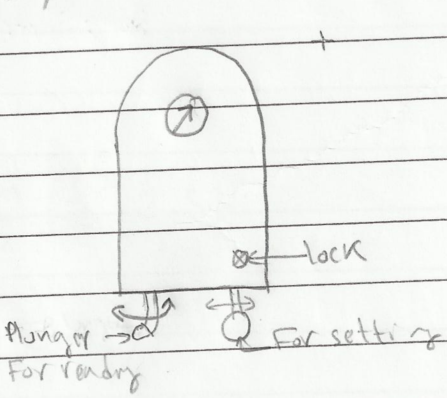
↳ P_b (Base pitch)

$\overline{aC} = \widehat{AC}, \overline{bC} = \overline{BC}$



$$P_b = \frac{\pi D_B}{z} = \frac{\pi m z \cos\psi}{z} = \pi m\cos\psi$$

_ Keilpart:



Move down or up (one direction) and read min. reading (R_g).

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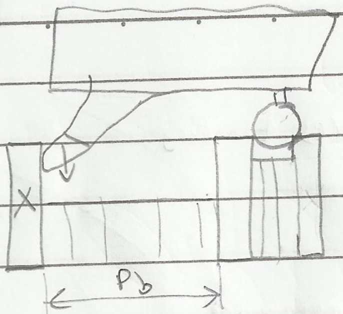
$P_{b_m} = \delta_b + P_b$

$P_{b_m} = (R_g - R_{std}) + P_b$

R_g ↑ on gear; R_{std} ↑ calculated; P_b ↑ intial



(2)

Experimental procedure:

1- D_o
2- Z
3- m
4- m_{std}
5- Calculate base pitch: $P_b = \pi m \cos\psi$
6- Select the suitable keilpart according to module (m)
7- Set the keilpart opening to be suitable to measured gear
8- Take the reading on gear tooth as in (1) [least reading]
9- Build a block gauge combination as in (2)
10- Using keilpart to take reading on combination (R_{std}) [least reading]
11- $\delta = R_g - R_{std}$
12- $P_{b_m} = (R_g - R_{std}) + P_b$

- Error → Error in division during manufactory
  → Error in base circle

* Determination of error in pitch circle:

1- Take reading over all teeth of gear
2- Consider average of readings
3- Compare with standard reading → $R_{av} - R_{std}$
→ $\delta_{av} = R_{av} - R_{std} \Rightarrow D_b = \dfrac{(\delta_{av} + P_b) Z}{\pi}$

$\delta_{D_b} = D_{b_m} - m Z \cos\psi = Z \delta_{av}$

K&A ANDLOSYA

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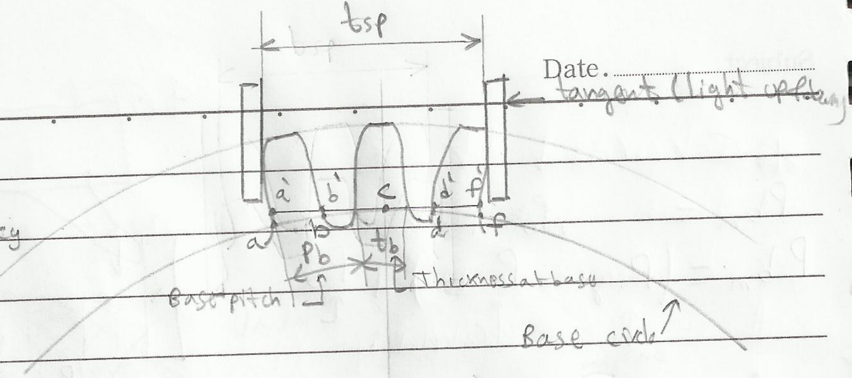
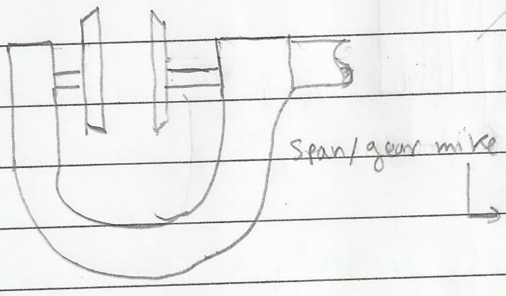


* Span length

- Anvil desingn ensures tangency



└ vernier for large gear

- $\overline{a'c} = \overset{\frown}{ac}$

  $\overline{a'f'} = \overset{\frown}{af}$

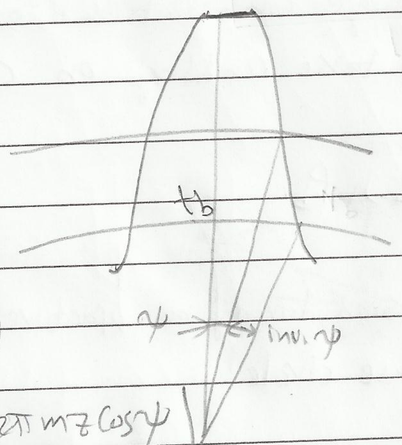
  $t_{sp} = \overline{af}$

- $t_{sp} = (n_{sp}-1)P_b + t_b$; $n_{sp} = \frac{Z}{g}$ → Approximate to larger

  $P_b = t_{sp_{n+1}} - t_{sp_n}$ └→ $\frac{360}{20\times 2} = g$

  └→ ψ

$$t_{sp} = (n_{sp}-1)\pi m\cos\psi + m\left(Z\cos\psi \; inv.\psi + \frac{\pi}{2}\cos\psi\right)$$



$$t_b = 2\left(r_b \, inv\psi + \frac{2\pi r_b}{4\times Z}\right)$$

$$t_b = 2\left(\frac{mZ\cos\psi}{2} inv.\psi + \frac{2\pi mZ\cos\psi}{4\times Z\times 2}\right)$$

$$t_b = mZ \, inv\psi \cos\psi + \frac{\pi}{2} m\cos\psi$$